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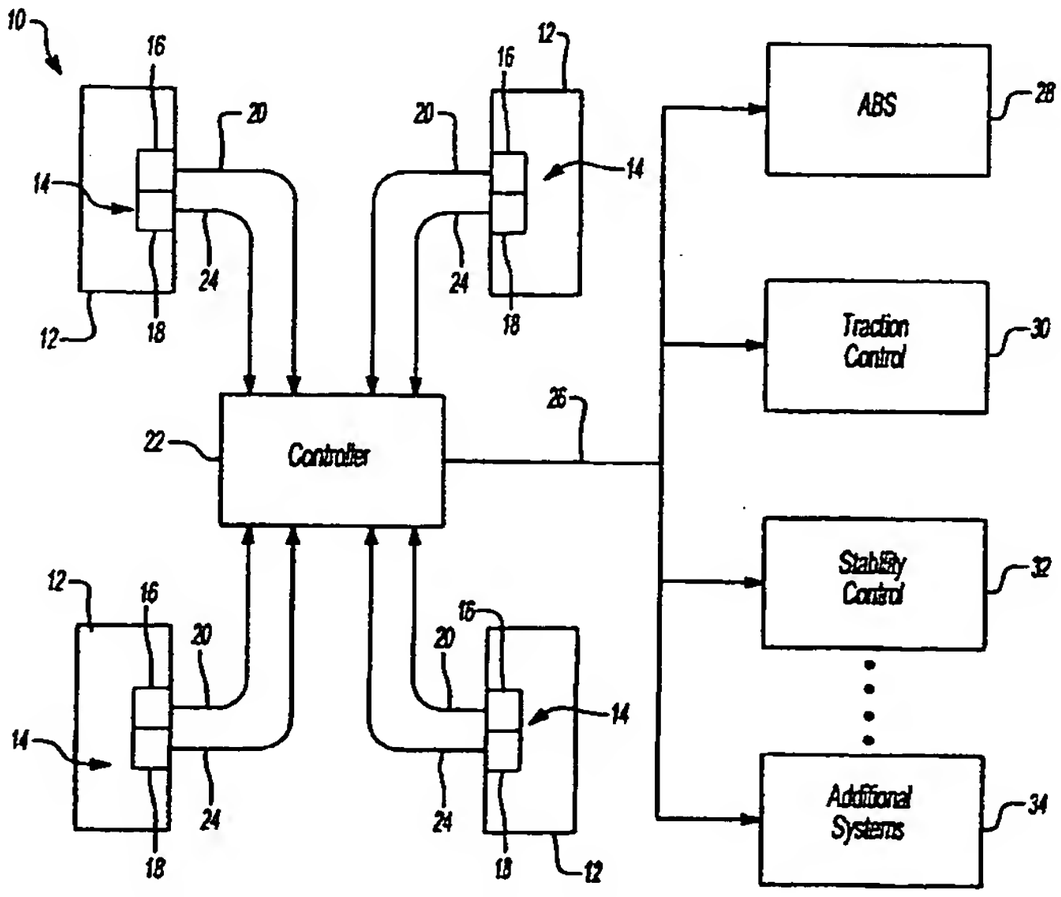

(57) Abstract: A vehicle control system (10) uses tire characteristic information such as tire pressure and temperature for vehicle systems such as anti-lock brake systems (ABS) (28), traction control systems (320), and stability control systems (32). Variances in tire temperature and pressure can affect the tire radius dimensions, which is used to calculate vehicle speed and individual tire rotation speed. This speed data is the basic foundation for generating control output signals for ABS (28), traction (30), and stability (32) control systems. The control system includes sensors (14) for measuring tire pressure and temperature during vehicle operation as input to the ABS (28), traction (30), and stability (32) control systems and to modify output control signals for the ABS (28), traction (30), and stability control (32) systems.

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VEHICLE CONTROL SYSTEM WITH TIRE SENSOR ASSEMBLY

BACKGROUND OF THE INVENTION

This invention relates to a system that generates tire characteristic input data that can be used in various vehicle control systems.

Anti-lock brake systems (ABS), traction control systems, and stability control systems are used on vehicles to optimize vehicle performance and safety. These systems measure vehicle speed and individual wheel speed and base output control signals on these measurements. The systems use a tire radius dimension to calculate the wheel speed at each of the vehicle wheels and to calculate the overall vehicle speed. The tire radius dimension is programmed into the system based on the type of tire on the vehicle and the optimal operating tire pressure.

Changes in tire pressure and tire temperature can vary the tire radius dimension. For example, a tire with low pressure will have a smaller tire radius. Thus, the ABS and traction control and stability control systems will be calculating wheel and vehicle speed based on a tire radius dimension that is different than the actual tire radius.

Some vehicles have tire pressure monitoring systems but, traditionally these systems measure tire pressure and indicate to the vehicle operator when the tire pressure falls below or exceeds a predetermined optimal operating tire pressure. There is no communication of any tire characteristic to the various control systems.

Thus, it is desirable to have a system that uses tire characteristic data measured during vehicle operation to increase the accuracy of ABS, traction control, and stability control systems, as well as overcoming the other above mentioned deficiencies with the prior art.

SUMMARY OF THE INVENTION

A vehicle control system includes a sensor assembly for monitoring tire characteristics. Tire characteristic data is transmitted to a controller that uses the data for generating output control signals for various vehicle systems such as anti-lock brake systems (ABS), traction control systems, and stability control systems.

In the preferred embodiment, the sensor assembly includes a sensor component for measuring tire pressure. The sensor generates a tire pressure signal, which is transmitted to the controller. The controller modifies the output control signals for the ABS and traction control and/or stability control systems based on the tire pressure signal.

Additionally, the sensor assembly can include a sensor component for measuring tire temperature. The sensor component generates a tire temperature signal that is transmitted to the controller. The controller modifies the output control signals for the ABS and traction control and/or stability control systems based on the tire temperature signal.

The subject system increases accuracy and optimizes vehicle performance and safety. These and other features of the present invention can be best understood from the following specifications and drawings, the following of which is a brief description.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a schematic diagram of a vehicle control system incorporating the subject invention.

DETAILED DESCRIPTION OF A PREFERRED EMBODIMENT

A vehicle with a control system is generally indicated at 10 in Figure 1. The vehicle includes a plurality of tires 12 that are mounted for rotation with vehicle wheels (not shown). Each tire 12 includes a sensor assembly 14 that measures at least one tire characteristic.

The sensor assembly 14 preferably includes a first sensor component 16 for measuring tire pressure at each tire 12 and a second sensor component 18 for measuring tire temperature at each tire. The first sensor component 16 generates a tire pressure signal 20 that is transmitted to a processor or controller 22. The second sensor component 18 generates a tire temperature signal 24 that is transmitted to the controller 22. The controller 22 can be any type of microprocessor or similar computational device known in the art and can be configured as a single central controller or a plurality of controllers.

The controller 22 generates an output control signal 26 that is transmitted to various vehicle subsystems. The controller 22 uses the information supplied by the tire pressure 20 and tire temperature signals 24 to modify control signals for vehicle subsystems such as an anti-lock brake system 28, a traction control system 30, a stability control system 32, or other vehicle control subsystems 34. The operation of these ABS 28, traction control 30, and stability control 32 systems are well known in the art and will not be discussed in detail.

The ABS 28, traction control 30, and stability control 32 systems use the tire radius dimension to calculate the wheel speed at each of the vehicle wheels and to calculate the overall vehicle speed. Changes in tire pressure and tire temperature, resulting in the tire being over or under inflated, varies the tire radius dimension. For example, a tire with low pressure will have a smaller tire radius than a tire having a higher tire pressure. The controller 22 uses the data from the tire pressure 20 and tire temperature signals 24 to determine the actual tire radius during vehicle operation. Thus, the ABS 28, traction control 30, and stability control 32 systems will have more accurate wheel and vehicle speed calculations when the actual tire radius information is used.

The controller 22 can also use tire pressure and temperature information as expected inputs for the ABS, traction control, and stability control system algorithms. For example, an extremely cold, over inflated tire will have a lower coefficient of friction than a warm, properly inflated tire. The controller 22 can use the tire pressure and temperature data to generate optimal control signals 26 for the ABS 28, traction control 30, and stability control 32 systems to account for these temperature and pressure differentials that occur during vehicle operation. Further, the vehicle can include a sensing device for monitoring ambient temperature. The ambient temperature information can be used to indicate possible icy road conditions.

Also, as another example, over inflated tires affect the rollover stability of a vehicle. The control signal to the stability control system 32 is preferably modified or optimized by the controller 22 when an over inflated tire is identified.

The sensor assemblies 14 can continuously monitor tire characteristics during vehicle operation or can intermittently measure the tire characteristics during

vehicle operation at predetermined intervals. Further, it should be understood that the sensor assembly 14 can include additional sensor components for monitoring other tire characteristics or can utilize only one of the sensor components 16, 18.

The system could also include a sensor or other similar device to identify a spare tire that has been installed on the vehicle to replace a flat tire. Typically, a spare tire is smaller than a factory installed tire and thus, the tire radius is smaller. The controller 22 uses the spare tire radius information to adjust speed control for the ABS 28, traction control 30, and stability control 32 systems.

The system could also use other vehicle information in combination with the tire information to modify system control signals. For example, the vehicle could include brake temperature sensors for monitoring brake temperature. An increase in brake temperature over a predetermined level could indicate either a hot tire resulting from operating at a non-optimal tire pressure, a hot brake approaching a brake fade condition, or a hot wheel bearing. By measuring tire pressure and brake temperature the controller 22 can use the information to modify the control signal to the ABS 28, traction control 30, and/or stability control 32 systems.

Vehicle loading information can also optionally be used to modify vehicle control signals. The system can include a load sensor mounted to a vehicle chassis for monitoring vehicle load. Optimal tire pressure can vary for an unloaded to a loaded condition on a vehicle. The controller 22 can use information from the tire pressure and load sensors to modify control signals for the ABS 28, traction control 30, and stability control 32 systems as well as using the information to determine or recommend an optimal tire pressure.

A transponder device can optionally be embedded in the tire with a continuous loop antennae. The transponder device provides traceability for every tire based on a unique transponder code. The information can be used for installation purposes, recall, disposability purposes, warranty purposes, etc. Once the controller 22 identifies the tire based on the code, the information can be cross-referenced with stored data to determine optimal tire pressures.

The system can also use the tire pressure information for diagnostic purposes. For example, if a wheel speed sensor in the ABS system 38 stops generating a signal but the system is still generating a tire pressure signal then the

tire pressure information can be used as a double check. Also, if information in the stability 32 or traction control 30 systems tends to indicate there might be system sensor drift on yaw or steering angle, the controller 22 might not need to compensate if a low pressure tire has been identified.

The system could also include a recorder device, similar to an airplane flight recorder, which gathers data from tires and other vehicle systems for accident reconstruction purposes. The flight recorder records during normal operation through the end of the crash, i.e. the recorder records pre-crash information, post-crash information, and information generated during the crash. A crash can be detected or determined by any one of a number of factors such as detecting a signal to inflate the air bags, detecting extremely rapid deceleration of the vehicle, measuring seat belt tension, measuring position of the occupant, sensing a roll-over condition, or sensing any other abnormal vehicle event. Detecting an airbag deploy signal, roll-over warning signal, or other signal indicating an abnormal vehicle event may be done by monitoring the vehicle bus, for example. Detecting rapid deceleration may be done by using information from the ABS system 28 or by independently monitoring vehicle speed. Changes in occupant position can be determined by using seat sensor information indicating sudden changes in weight distribution on the seat or by using optical sensors such as a camera indicating an occupant rapidly lurching forward, for example. The stored information for the tire should be pre-crash information to accommodate tire blowouts.

The subject control system 10 increases accuracy and optimizes vehicle performance and safety. Although a preferred embodiment of this invention has been disclosed, a worker of ordinary skill in this art would recognize that certain modifications would come within the scope of this invention. For that reason, the following claims should be studied to determine the true scope and content of this invention.

CLAIMS

1. A vehicle control system comprising:

at least one tire having at least one tire characteristic that varies tire radius during vehicle operation;

a sensor assembly for measuring said tire characteristic and generating a tire characteristic signal; and

a controller for receiving said tire characteristic signal and generating a control system output signal based on said tire characteristic.

2. A system according to claim 1 wherein said tire characteristic is tire pressure.

3. A system according to claim 1 wherein said tire characteristic is tire temperature.

4. A system according to claim 1 wherein said at least one tire characteristic comprises a plurality of tire characteristics that vary said tire radius during vehicle operation including a tire pressure characteristic and a tire temperature characteristic.

5. A system according to claim 4 wherein said sensor assembly includes a first sensor component for measuring tire pressure and generating a tire pressure signal and a second sensor component for measuring tire temperature and generating a tire temperature signal.

6. A system according to claim 1 wherein said at least one tire comprises a plurality of tires each having one of said sensor assemblies.

7. A system according to claim 1 wherein said control system output signal is transmitted to an anti-lock braking system.

8. A system according to claim 1 wherein said control system output signal is transmitted to a traction control system.

9. A system according to claim 1 wherein said control system output signal is transmitted to a stability control system.

10. A vehicle control system comprising:

a plurality of tires;

a pressure sensor assembly for measuring tire pressure and generating a tire pressure signal for each of said tires;

a controller that receives said tire pressure signals and modifies a control system output signal based on measured tire pressure at each of said tires.

11. A system according to claim 10 wherein said control system output signal is transmitted to a plurality of vehicle control subsystems.

12. A system according to claim 11 wherein said control subsystems include an anti-lock brake system, a traction control system, and a stability control system.

13. A system according to claim 11 including a temperature sensor assembly for measuring tire temperature and generating a tire temperature signal for each of said tires, said tire temperature signals being transmitted to said controller for modifying said output signal based on measured tire temperature at each of said tires.

14. A method for controlling a vehicle system comprising the steps of:

(a) measuring at least one tire characteristic;

(b) generating a tire characteristic signal based on the measurement of step (a);

(c) modifying a control system output signal in response to the tire characteristic signal.

15. A method according to claim 14 wherein step (a) includes continuously measuring the tire characteristic during vehicle operation.

16. A method according to claim 14 wherein step (a) includes intermittently measuring the tire characteristic during vehicle operation.

17. A method according to claim 14 wherein the tire characteristic is tire pressure.

18. A method according to claim 14 wherein the tire characteristic is tire temperature.

19. A method according to claim 14 wherein step (a) is further defined as measuring multiple tire characteristics including tire pressure and tire temperature and wherein step (b) is further defined as generating a tire pressure signal based on measured tire pressure and generating a tire temperature signal based on measured tire temperature and wherein step (c) is further defined as modifying the control system output signal based on the tire pressure and temperature signals.

20. A method according to claim 14 including the step of transmitting the control system output signal to at least one of a anti-lock braking system, a traction control system, or a stability control system.

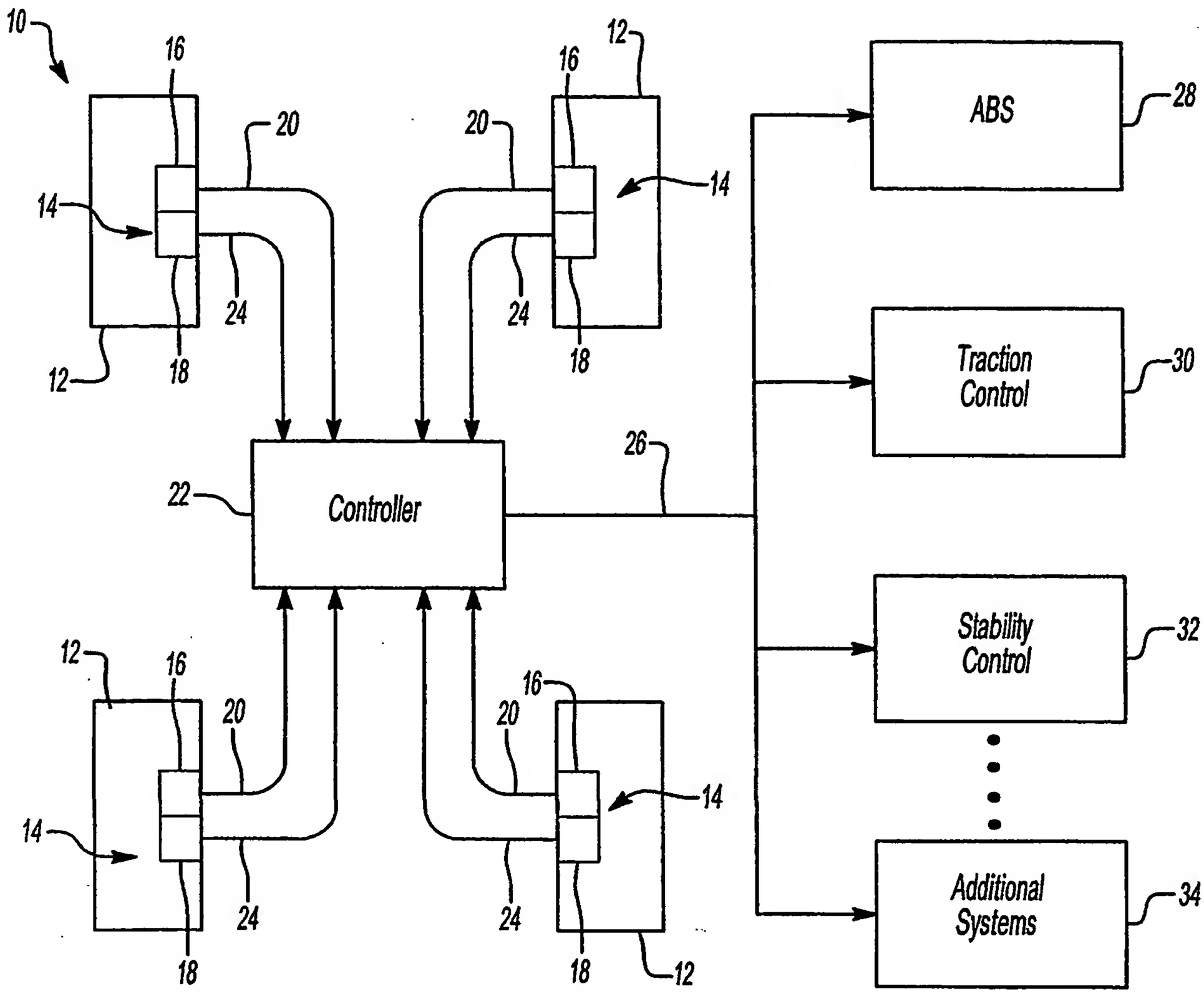

Fig-1

INTERNATIONAL SEARCH REPORT

Inte Application No
PCT/US 02/01405

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 B60C23/04 B60T8/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 B60C B60T

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, WPI Data, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0 808 731 A (TOYOTA MOTOR CO LTD) 26 November 1997 (1997-11-26) page 2, line 47-50 page 3, line 3 - line 15 page 6, line 10 - line 30 page 10, line 59 -page 11, line 8; figures 1,10	1-6,14, 15,17-19
X	PATENT ABSTRACTS OF JAPAN vol. 1997, no. 08, 29 August 1997 (1997-08-29) -& JP 09 109871 A (NISSAN MOTOR CO LTD), 28 April 1997 (1997-04-28) abstract; figures 1,2	1,2,6,7, 10,12, 14,15, 17,20

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[X] Further documents are listed in the continuation of box C. [X] Patent family members are listed in annex.

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"E" earlier document but published on or after the international filing date
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Date of the actual completion of the international search	Date of mailing of the international search report
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Name and mailing address of the ISA	Authorized officer
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INTERNATIONAL SEARCH REPORT

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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
P,X	WO 01 08908 A (CESARINI RICCARDO ;PIRELLI (IT); CARETTA RENATO (IT); MANCOSU FEDE) 8 February 2001 (2001-02-08) page 28, line 14 -page 29, line 36; claims 4,9; figure 12	1,2,6,7, 9-12,14, 15,17,20
X	US 5 292 184 A (TAKATA KOJI) 8 March 1994 (1994-03-08) abstract column 1, line 16 - line 18 column 1, line 34 - line 36 claims 1,14,15; figure 1	1,2,6-8, 14,15, 17,20
X	US 5 934 768 A (MIYAKE KATSUYA) 10 August 1999 (1999-08-10) abstract column 8, line 49 - line 67; figures 4,11	1,2,6,7, 10,11, 14,15,17
X	US 5 839 801 A (FERGUSON STEVEN C) 24 November 1998 (1998-11-24) column 2, line 2 - line 67; claim 1; figure 1	1,2,8, 10,14, 15,17

Form PCT/ISA/210 (continuation of second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

Information on patent family members

Inte Application No
PCT/US 02/01405

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 0808731 A	26-11-1997	JP 9309304 A	02-12-1997
		EP 0808731 A2	26-11-1997
		US 5913241 A	15-06-1999
JP 09109871 A	28-04-1997	NONE	
WO 0108908 A	08-02-2001	AU 6435300 A	19-02-2001
		BR 0012893 A	16-04-2002
		WO 0108908 A1	08-02-2001
US 5292184 A	08-03-1994	JP 4283665 A	08-10-1992
		DE 69205611 D1	30-11-1995
		DE 69205611 T2	25-04-1996
		EP 0508146 A2	14-10-1992
US 5934768 A	10-08-1999	JP 9240446 A	16-09-1997
US 5839801 A	24-11-1998	NONE	